Route Choice Analysis of Bus-use Commuters in Yangon, Myanmar

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Abstract

This paper surveys the travel behavior of bus-use commuters in Yangon, Myanmar and analyzes the bus route-choice models with the collected data. The revealed preference survey combined with the stated-preference survey was implemented in the western and southern parts of Yangon City. 1240 choice data of 169 individuals were collected including 169 RP choice data and 1080 SP choice data. Then, the bus route-choice is analyzed with a binary logit model. After checking the reliability of SP data by estimating the SP model, the RP/SP combined model is estimated. Additionally, the RP/SP model incorporating the monthly income is also estimated. They show that the bus-use commuters prefer the high-quality buses to the truck bus. They also show that the estimated value of travel time is about 10.1 Kyats/minute and it increase as the monthly income increases.

Key Words: Urban bus, route choice, SP/RP combined model, Yangon, Myanmar

Introduction

Yangon is the most important commercial center of Myanmar with about 4.1 million people in the area of 598.76 km2 (United Nations, 2007). There are mainly four types of transportation modes available in Yangon: private car, rail, taxi and bus. The vast majority of urban transportation relies on the bus transportation in Yangon. According to Zhang et al. (2008), the modal share of bus transportation in Yangon reaches 84%. This is because of the difficulties of the car ownership, the low quality of rail service, and the regulation of motorbike and para-transit service in the central business district.

However, as Kato et al. (2010) points out, the quality of urban bus service in Yangon is unacceptably bad. The most of buses are second-handed and ill-maintained. They often have the engine troubles even during the operation. They are inconvenient and uncomfortable due to the ill-operated service. No time table and no route map are shown to the public. Not only the visitors but also the local people have the difficulties to use the local bus system. Although many bus routes are operated in a wide network of the City, they are sometimes over-crowed due to the lack of vehicle's capacity. The traffic congestion caused by the lack of road capacity leads to the chronic delay and unpunctuality of bus service particularly during the peak hours. The bus users have to wait for a long time at the bus stops to wait a next bus. The bus stops or terminals are also not well-designed. Some bus passengers must walk several minutes to transfer the buses at the bus stops/terminals. As the urban area grows, the travel distance has been also longer. Many local people have to travel long in the congested vehicles during the peak hours. To improve the quality of urban bus service is critically important in Yangon.

This paper surveys the behavior of local bus users in Yangon. The bus-use commuters are surveyed because the most serious problems occur mainly during the morning peak hours. Then, their bus route-choice is analyzed with the collected data. The bus route-choice model incorporates the main factors of bus service including the travel time, waiting and transfer at the stops/germinal and travel cost. The accessibility of bus users can be evaluated with this model.

The paper is organized as follows. Next section summarizes the characteristics of bus transportation service in Yangon. Then, section 3 presents the local survey on bus-use commuter's behavior. The bus route-choice model based on RP/SP combined model and its estimation results are shown in section 4. Finally, the achievements are discussed.

Bus Transportation Service in Yangon

There are the two types of local bus services in Yangon: the bus service given by bus companies and the bus service controlled by the bus control committees (BCCs). The bus companies are the large-scale private bus operators who own the bus vehicles, hire the drivers/conductors and operate the urban bus service in Yangon. The two bus companies are now supplying the bus service in Yangon: the Golden City Link Co. (GCL) and the Union of Myanmar Economic Holdings Limited (UMEHL). The BCCs are the non-profit organizations which control the small-scale individual bus owners. The individual bus owners own the bus vehicles and lease the bus vehicles to the drivers and conductors. The individual bus owners must belong to one of the BCCs. There are a number of individual bus owners in Yangon.

There are the two types of bus fare systems in Yangon: a distance-based fare system and a constant fare system. First, the distance-based fare system is introduced into the bus routes controlled by the BCCs except for some special bus routes. A unique distance-based fare system is shared among all the BCCs: the minimum fare is 50 Kyats; the fare rises by 50 Kyats for every 5-mile after 5-mile travel; and the maximum fare is 250 Kyats. Second, the GCL has the constant fare system. Its fare is 300 Kyats per ride. Third, the UMEHL has the two types of fare systems. The one is the constant fare system which is applied to the routes where the air-conditioned city bus service is provided. Its fare is 200 Kyats per ride. The other is the distance-based fare system which is the same as that of BCCs. Generally, the bus fare is collected by the conductors serving in the bus vehicle or at the entrance of the vehicle. Note that the GCL exceptionally introduces the ticket system, in which the bus conductor sells the tickets for collecting the fare.

No time table of bus operation is available in Yangon. Although the rough information about the service frequency is widely known by the local people, it is not presented explicitly anywhere. As there is no information about the schedule of the first and last bus service of the day, they are not guaranteed at all. As the bus number is written only in Myanmar language, it is almost impossible to identify the destination for the people who have no experience to use the bus. As no information about the bus stop is presented, the visitors have no way to know the name of bus stop. Additionally, no information about the fare table is presented at the bus stops. The bus operation is also not well-controlled in Yangon. In practice, only the cycle time of bus operation is monitored by the BCC at the control gate.

According to Kato et al. (2010), the local buses can be categorized into the following six types from the viewpoints of their function, design and capacity: city bus (air-conditioned); city bus (non-air-conditioned); mini bus; Dyna/Canter; Hilux; and other. Dyna/Canter and Hilux are the trucks which are redesigned into the passenger-use by adding the roofs and seats on the body. They are widely called the "truck bus" by local people in Yangon. The majority of buses in operation are the truck buses. The vehicles controlled by the BCCs are mainly the small-scale bus vehicles, including the Mini bus, Dyna/Canter, and Hilux.

The average length of a bus route is about 32 km. Note that the distance from the northern end to the southern end or the distance from the eastern end to the western end of Yangon City is about 30 km each. The most of bus routes run directly between the suburban areas and the central business district. In other words, the bus network in Yangon is characterized as a "point-to-point" network. In many bus routes, the service frequency during the peak hours in the morning or in the evening is higher than the service frequency during the off-peak hours. For example, according to our interviews, the MaThaTa BCC operates the bus service every 5 minutes from 5:00 a.m. to 7:00 a.m.; every 3 minutes from 7:00 a.m. to 9:00 a.m.; every 7 minutes from 10:00 a.m. to 3:00 p.m.; and every 3-5 minutes from 5:00 p.m. to 7:00 p.m.

Local Survey on Bus-use Commuters in Yangon

The study team including the authors made the local survey on the urban bus-use traveler's behavior. The survey collects the data of sample-based bus-route-choice in Yangon City. The area where the survey was implemented is mainly the southern and western parts of Yangon City including the central business district (Lanmadaw township, Latha township, Pabedan township, Kyauktada township and Pazun Daung township), Ahlone township, Bahan township, Kyee Myin Daing township, Kamaryut township, Hlaing township, Hlaing Tharyar township, Insein township, Mayangone township, Mingalardon township (south area), North Okkalapa township, Sanchaung township, Tarmway township and Yankin township. These areas cover the two main roads and a number of bus routes connecting the sub-urban areas with the central business district.

The questionnaire sheets in the survey request the respondents to answer: (1) the daily commuting behavior in the morning including the origin and destination; departure time from home and arrival time to destination; travel mode used and the reason to choose it; routes used including the bus number and the reason to choose it; travel time and travel cost; average waiting time at bus stop; available alternative routes; (2) individual attributes including personal information such as age, gender, job, household income and the number of family members; the addresses of home and workplace; and (3) travel preference data including the priorities among the different service factors; customer satisfaction regarding the current bus system including fare, travel time, frequency and other service; and the stated preference (SP) choice among the hypothetical routes. As for the stated preference survey, the respondents are requested to choose the best route among the given route choice set from their home to their workplaces. The 16 types of hypothetical choice problems are prepared in advance. A surveyor randomly selects the two or three problems and asks them to a respondent. The travel time, travel cost, transfer time, waiting time and access/egress time and the bus type of each route option are shown to the respondent in the stated preference question.

The bus travel survey takes 10 to 15 minutes per respondent. The bus stops where the bus travel surveys were made are shown below: Bus stop of line No.48 and Pauktaw; Insein Garden; Bying Naung Junction and Golden bus line No.2 bus stop near that; and Thamine Junction. They are selected mainly because there are two or more bus routes from them to the central business district. The interviews are made during peak hours in the evening. This is first because we wanted to collect the bus-use commuters. The reason for collecting the data of commuters is that the major traffic problems regarding the urban bus transport are caused by the commuter's traffic during the peak hours of morning or evening on weekdays. The second reason for making the interviews in the evening is because we consider that the commuters do not accept the interviews in the morning due to their time constraints. The surveyors selected randomly the bus passengers who are getting off the bus at the bus stop/terminal and interviewed them with the paper-based questionnaire sheets.
The study team hired 20 local surveyors, mainly the master-course students of the Yangon Technological University. The surveys were implemented on November 9 to 21, 2008. They were all the non-rainy weekdays. 593 individuals were interviewed and 2 379 route-choice results were collected. 1 389 route-choice data including the RP data of 169 of individuals and the 1 220 SP data of 465 individuals are valid among them. The share of RP-based data is low among all the route-choice data because many of respondents do not have the alternative bus route from their home to their workplaces in their daily commuting.

The characteristics of survey respondents are summarized in Table 1. First, the male respondents are more than the female respondents. This reflects the gender share of local commuters in Yangon. The respondents of 18 to 59 years old are dominant. This is because only the commuters are interviewed. The share of age groups from 18 to 59 may reflect the age distribution of population in Yangon. About half of the respondents are the employees at the private companies while one third of the respondents are the public servants. The share of self-employees is low probably because the most of self-employees do not commute or because they do not use the buses for commuting. The respondents of 30,000 – 60,000 Kyats are the most among the income groups. The higher the income is, the lower the bus-use commuters are. The average monthly income of respondents is 85 968 Kyats. As Zhang et al. (2008) shows, the increase in income will bring about a potentially large increase in car usage and consequently reduction in transit systems. About 40 % of respondents arrive at their workplaces during 8:00-8:59. This is mainly because the working time starts at 9:00 in many offices in Yangon. However, interestingly, the respondents arriving at destinations during 7:00-7:59 or 9:00-9:59 are also observed. This may be because they shift the departure time to avoid the traffic congestion during the peak hours in the morning.

Estimation of Bus Route-choice Model

Bus Route-choice Model. We estimate the bus route choice model with the data collected in the bus travel survey. A multinomial Logit (MNL) model is used to analyze the route choice of bus travelers. MNL model is one of the discrete choice models (*5*). In the mode, it is assumed that a consumer chooses an option discretely

Table 1 Characteristics of survey respondents (N=169)

Variables	Categories	Number of observations	Percentage (%)
Gender	Male	109	64.5
	Female	60	35.5
Age	Under 17	1	0.6
	18 - 29	61	36.1
	30-39	49	29.0
	40-49	35	20.7
	50-59	22	13.0
	Over 60	1	0.6
Occupation	Private company	84	49.7
	Public servant	57	33.7
	Self-employment	28	16.6
Monthly income (Kyats)	Under 30,000	23	13.6
	30,000-60,000	65	38.5
	60,001-90,000	41	24.3
	90,001-120,000	15	8.9
	120,001-150,000	10	5.9
	Over 150,001	15	8.9
Arrival time in the morning	-6:00	3	1.8
	6:00-6:59	11	6.5
	7:00-7:59	42	24.9
	8:00-8:59	69	40.8
	9:00-9:59	35	20.7
	10:00-10:59	8	4.7
	11:00-	1	0.6

by maximizing his/her utility with the random factor. The conditional indirect utility function of a route from the one origin to the other destination is formulated as follows:

$$U_{od,r}^{n} = V_{od,r}^{n} + \varepsilon_{od,r}^{n} \tag{1}$$

where $V_{od,r}^{n}$ is the universal component of the indirect utility of an individual n when the rth route is chosen from zone o to d, and $\varepsilon_{od,r}^{n}$ is the error component of the utility function following the independently and identically distributed (iid) Gumbel. Then, the probability of choosing the rth route is chosen from zone o to d for individual n is derived as:

$$p_{od,r}^{n} = \frac{\exp\left(\lambda V_{od,r}^{n}\right)}{\sum_{r' \in R_{od}^{n}} \exp\left(\lambda V_{od,r}^{n}\right)} \tag{2}$$

where $p_{od,r}^{n}$ is the probability of choosing the rth route is chosen from zone o to d for individual n and λ is a scale parameter corresponding to the Gumbel distribution with $\lambda^2 = \pi^2 / 6\sigma^2$ (σ^2 is the variance of the Gumbel distribution) and zero mean.

The conditional indirect utility function of each route is assumed to be a linear function of explanatory variables as:

$$V_{od,r}^{n} = \sum_{m} \kappa_m X_{m,od,r}^{n} \tag{3}$$

where κ_m: unknown parameters and $X_{m,od,r}^{n}$: the mth explanatory variable of the rth route from zone o to d. Since the unknown parameters λ and κ_m cannot be estimated independently, we estimate the unknown parameters ρ_m by using the following utility function:

$$\lambda V_{od,r}^{n} = \sum_{m} \rho_m X_{m,od,r}^{n} \tag{4}$$

The unknown parameters are estimated by maximizing the likelihood function with the individual data collected in the bus travel survey. The likelihood function is defined as:

$$L(\mathbf{\rho}) = \prod_{od} \prod_{r} \prod_{n} \left(p_{od,r}^{n}\right)^{\delta_{od,r}^{n}} \tag{5}$$

where $\delta_{od,r}^{n}$ is 1 if individual n chose the rth route is chosen from zone o to d; and 0 if not.

RP/SP combined model. The data collected in our survey includes RP data as well as SP data. SP data has more biases than RP data. For example, the respondents cannot imagine the hypothetical options appropriately. They may feel confused when answering questions due to bad explanation by the surveyors or improper ordering of questions. On the other hand, the SP data is useful to forecast the choice of a new option or to analyze the sensitivity of the level-of-service which is important from the transportation policy but which cannot be observed in reality. (Hensher, 1994; Louviere et al., 2000) To model the individual's choice behavior based on SP data, an RP/SP combined model is applied here (Ben-Akiva and Morikawa, 1990). This model is especially used to correct SP reported biases by introducing the RP information.

Let the conditional indirect utility functions of RP data and SP data be $U_{od,r}^{n,RP}$ and $U_{od,r}^{n,SP}$ respectively. By following equation (1), they are defined as

$$U_{od,r}^{n,RP} = V_{od,r}^{n,RP} + \varepsilon_{od,r}^{n,RP} \tag{6}$$

$$U_{od,r}^{n,SP} = V_{od,r}^{n,SP} + \varepsilon_{od,r}^{n,SP} \tag{7}$$

The RP/SP combines model assumes that SP utility function $U_{od,r}^{n,SP}$ has a different variance $\sigma_{od,r}^{n,SP}$ of the error term $\varepsilon_{od,r}^{n,SP}$ from the variance $\sigma_{od,r}^{n,RP}$ in RP utility function as follows:

$$\sigma_{od,r}^{n,SP} = \mu^2 \sigma_{od,r}^{n,RP} \tag{8}$$

where μ is an unknown scale parameter. As it is expected that there exist more biases in SP data than in RP data, the scale parameter μ is usually less than 1. We again assume that the error component of the utility function follows the independently and identically distributed (iid) Gumbel. Then, the probabilities of choosing an option in RP data and SP data are derived respectively as follows:

$$p_{od,r}^{n,RP} = \frac{\exp\left(\lambda V_{od,r}^{n,RP}\right)}{\sum_{r' \in R_{od}^{n,RP}} \exp\left(\lambda V_{od,r}^{n,RP}\right)} \tag{9}$$

$$p_{od,r}^{n,SP} = \frac{\exp\left(\mu\lambda V_{od,r}^{n,SP}\right)}{\sum_{r' \in R_{od}^{n}} \exp\left(\mu\lambda V_{od,r}^{n,SP}\right)} \tag{10}$$

The unknown parameters μ and $\boldsymbol{\rho}$ can be estimated by maximizing the following likelihood function:

$$L^{RP/SP}(\boldsymbol{\rho}, \mu) = \left(\prod_{od} \prod_{r} \prod_{n} \left(p_{od,r}^{n,RP}\right)^{\delta_{od,r}^{n,RP}} \right) \left(\prod_{od} \prod_{r} \prod_{n} \left(p_{od,r}^{n,SP}\right)^{\delta_{od,r}^{n,SP}} \right) \tag{11}.$$

Estimation results. First, we estimate the MNL model only with the SP data to test the reliability of SP data. This is because the SP survey has more biases than RP survey although the respondents show the high interests in our survey. The individual's choice set is assumed to include the two routes. This is because the respondents answered the choice of two alternatives in both RP and SP surveys. The explanatory variables we use are *in-vehicle time*, *waiting time*, *transfer time*, *dummy for transfer*, *access and egress time*, *total travel time*, *travel cost*, and *dummy of bus type*. The *dummy for transfer* is defined as 1 if the route includes one or more transfers and 0 if not. The *dummy of bus type* is defined as 1 if the bus operated in the route is "city bus" and 0 if not. The estimated results of the four models are shown in Table 2.

The signs of all parameters are fine. Most of the parameters for level-of-service variables are statistically significant. However, the transfer time or the dummy for transfer is not significant. Probably the respondents found the difficulties to find the difference of transfer time among the given choice options. However, in general, it is expected that the respondents answer the reasonable choice after understanding the survey.

Table 2 Estimation results of SP models

Variable	Unit	Model SP1		Model SP2	
		Coefficient	t-statistic	Coefficient	t-statistic
In-vehicle time	Minutes	-0.0345	-7.62	-0.035	-7.70
Waiting time	Minutes	-0.0366	-2.37	-0.0381	-2.40
Transfer time	Minutes	-0.0102	-0.75		
Dummy for transfer				-0.1253	-1.02
Access and egress time	Minutes	-0.0578	-3.44	-0.0584	-3.50
Travel cost	Kyats	-0.0041	-3.70	-0.0043	-3.82
Dummay of bus type		0.432	4.48	0.4315	4.47
McFaddens's Rho-squared			0.0447		0.0449
Number of observation			1080		1080

Table 3 Estimation results of RP/SP combined models

Variable	Unit	Model SP/RP1		Model SP/RP2		Model SP/RP3	
		Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
In-vehicle riding time	Minutes	-0.0677	-3.24	-0.055	-3.17		
Waiting time	Minutes	-0.0539	-1.83	-0.0518	-2.06		
Transfer time	Minutes	0.0271	0.77				
Dummy for transfer				-0.0631	-0.25		
Access and egress time	Minutes	-0.0957	-2.70	-0.0875	-2.64		
Total travel time	Minutes					-0.0547	-3.36
Travel cost	Kyats	-0.0072	-2.84	-0.006	-2.94	-0.0054	-3.03
Travel cost/income							
Dummay of bus type		0.8655	3.04	0.6928	2.78	0.5899	2.89
Scale parameter		0.4133	2.44	0.5746	2.57	0.7675	3.14
Value of in-vehicle riding time	Kyats/minute		9.40		9.17		
Value of total travel time	Kyats/minute						10.13
McFaddens's Rho-squared			0.046		0.046		0.059
Number of observation			1240		1240		1240

Then, we estimate the RP/SP combined model. As for the RP data, the explanatory variables of unused route are prepared based on the observed data. The estimation results are shown in Table 3. In the same way as the results of SP model estimation, the *transfer time* or the *dummy for transfer* is not significant in Model RP/SP1 and Model RP/SP2. Additionally, the sign of *transfer time* in Model RP/SP1 is positive. The Model RP/SP 3, in which the *total travel time* is used, has the best fitness among the various models we tried to estimate. The estimated scale

Table 5 Estimation result of RP/SP combined model incorporating monthly income

Variable	Unit	Model RP/SP4	
		Coefficient	t-statistic
Total travel time	Minutes	-0.0625	-3.73
Travel cost	Kyats		
Travel cost/income		-186.3	-2.40
Dummay of bus type		0.6508	3.08
Scale parameter		0.6155	3.41
McFaddens's Rho-squared			0.055
Number of observation			1240

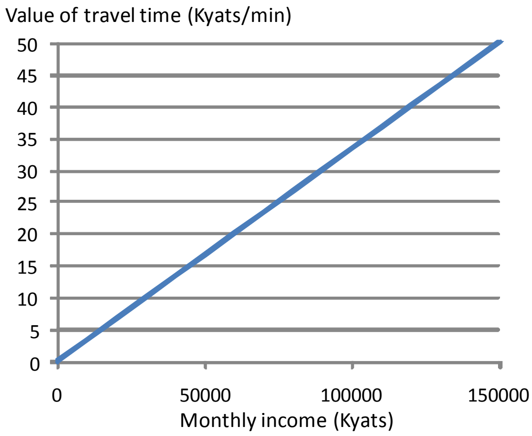

Figure 2 Monthly income vs. estimated value of travel time

parameters are also significant. They are less than unity. This means that the variance of error term in the utility function of RP data is significantly smaller from that of SP data as we expected. The estimated parameter of *dummy for bus type* is positive. This means that the bus-use commuters prefer the city-bus to the other types of bus. This reflects that the local people want to use the comfortable vehicle rather than the truck bus.

The estimated value of travel time is 10.13 Kyats/minute in Model RP/SP3. Zhang et al. (2008), using the SP-based modal-choice data in Yangon shows that the estimated value of travel time vary from 3 to 10 Kyats/minute which depend on the individual's income level. Then, we also estimate the RP/SP model incorporating the income. The *travel cost/income* is newly introduced instead of *travel cost*. This reflects the hypothesis that the route is chosen on the basis of not the travel cost directly but the share of travel cost among the total income. Table 5 shows the estimated parameters. Although the fitness of the model is worse than Model RP/SP3, the estimated parameters satisfy the expected conditions. All of the parameters are also significant. Then Figure 2 shows the monthly income versus estimated value of travel time based on the Model RP/SP4. This indicates that the value of travel time varies from 0 to 50 in the range of 0 to 150000 Kyats of monthly income. As the monthly income increases, the value of travel time is also higher. The estimated value of travel time may be higher than the estimated values shown by the previous study (Zhang et al., 2008). This is probably because the respondents in our survey are bus-use commuters only. The commuters mean the workers who earn the salary from some business. The workers have higher value of travel time than non-workers because the value of travel time is higher theoretically as the wage rate is higher. The previous study includes the students in addition to the workers and they may reduce the estimated value of travel time. Additionally, it is expected that the bus users earn higher income than the rail users. This is because the rail service in Yangon is so poor that the lower-income people tend to use it. The previous study includes the rail users whereas our study does not.

Conclusions

To our best knowledge, our study is the first attempt to analyze the route-choice behavior of bus users in Yangon. The estimated models are expected to contribute to bus operators, bus regulators and transportation planners. First, the bus operators can improve the business plans based on the detailed information of bus-use demand. Second, the bus regulators can also take the preference of bus users into considerations when they permit the bus route or bus vehicle to the bus operators. Third, the impacts of transportation policies on bus transportation demand can be forecasted. For example, the transportation policy for reducing the traffic congestion increases the bus service speed and this influences the bus-route choice of local people. Finally, the transportation policy regarding the bus transportation can be evaluated with the model. For example, the improvement of accessibility caused by transportation policy can be calculated as the monetary benefit by using the estimated model. The log-sum values derived from the multinomial logit model represents the traveler's welfare. This can be used in the benefit calculation during the process of cost-benefit analysis.

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